

Micro-cathode Arc Thruster PhoneSat Experiment (MAPRS)

Completed Technology Project (2012 - 2013)



Project Introduction

The Micro-cathode Arc Thruster Phonesat Experiment was a joint project between George Washington University and NASA Ames Research Center that successfully developed and integrated a fully operating electric plasma propulsion subsystem for CubeSats commanded by the Ames developed PhoneSat bus.

The integrated system was tested and evaluated successfully. A prototype version was integrated by the MAPERS team this summer, demonstrating the integration and control in the desired cubesat form factor. The integrated demonstration system consists of a Pulsed Plasma Unit operated by a phone and a commercial micro-controller that generates a plasma jet that comes out of the thruster head. The PPU has two main parts: an Inductor for Energy Storage (IES) and an Anode/Cathode Discharge (ACD) section. The latter is where the thruster head is located schematically. An anode made by nickel, a cathode made by titanium and a ceramic insulator form the thruster head. The anode and the cathode are connected to the PPU by copper wires and a metallic spring. The cathode itself is the actual solid propellant of the thruster.

These parts are mutually exclusive, meaning that the current only flows in one of them at the same time. An Inducted Gate Bipolar Transistor (IGBT) controls the current flow in both of the sections. The input of the entire system is received in form of a trigger pulse from the micro-controller. This pulse has a moderate amplitude of about 3 V with a specific period and waveform. The operation of the thruster can be split into two main steps, a charge and a discharge cycle. During the charge period, the power capacitor stores energy up to its maximum and the float voltage is used to charge the inductor. Current only flows in the IES section. At this time, the trigger pulse passes through the gate of the IGBT, causing a current flow from the collector to the emitter of the transistor, closing the circuit. At the end of this step, the inductor is charged to its maximum. In the discharge cycle, once the IES is completely charged, the trigger pulse is turned low. When there is no input at the gate, the IGBT is switched off. Therefore, any current flows from the collector to the emitter and a rapid discharge goes through the ACD section between the anode and the cathode. A peak voltage of several hundred volts is generated between both electrodes. Arc currents in the order of several tens of Ampere flow from the anode to the cathode. A plasma-jet is produced. Then, plasma flows through the carbon paint connection to the cathode, where the propellant material gets consumed.

Regarding the interface, the shipment of commands from the Phone was established through a serial port. Tests are done by sending commands that activate the trigger pulse and enable the various thruster channels. All three thrusters were successfully commanded and operated. Frequencies of 1, 2, 10, 25 and 50 Hz were tested, demonstrating activation at each frequency. The Smartphone interface was programmed in Android while the micro-controller interface was programmed in C++.



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PhoneSat Experiment

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Center Innovation Fund: ARC CIF

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This system has reached a TRL of 6 by being tested in relevant conditions of vacuum this summer at the Engineering Evaluation Laboratory at NASA Ames. Three different thrusters were fired at the same time.

Anticipated Benefits

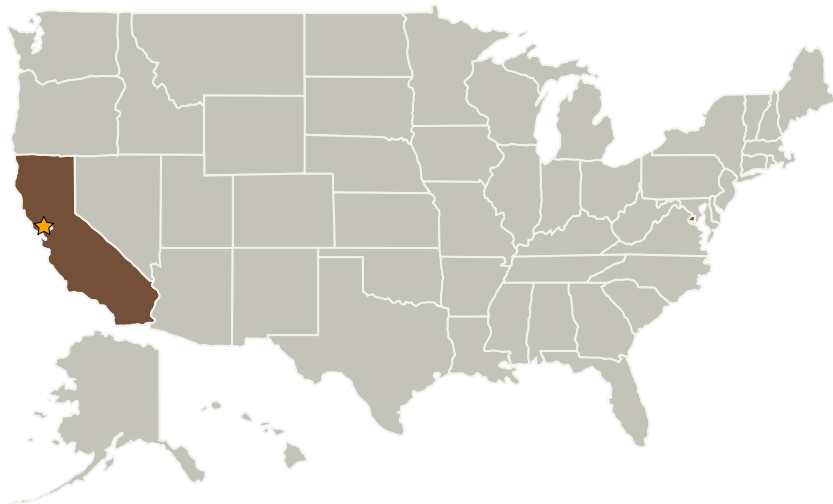
Will provide low thrust/propulsion/attitude control capabilities for small satellite platforms

Supports spacecraft and mission design activities for NASA Missions

Technology will support commercial small satellite projects.

Technology will support agencies interested in small spacecraft missions, such as Department of Defense.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Harry Partridge

Project Manager:

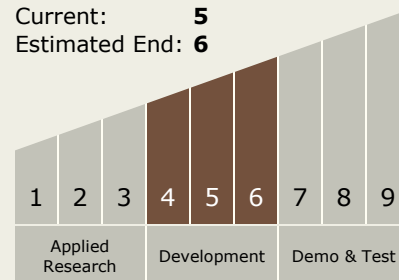
Elwood F Agasid

Principal Investigator:

Oriol Tintore Gazulla

Technology Maturity (TRL)

Start: 4
Current: 5
Estimated End: 6

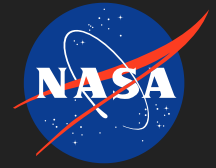


Technology Areas

Primary:

- TX01 Propulsion Systems
 - TX01.2 Electric Space Propulsion
 - TX01.2.3 Electromagnetic

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Co-Funding Partners	Type	Location
George Washington University	Academia	Washington, District of Columbia

Primary U.S. Work Locations	
California	District of Columbia

Stories

1676 Approval #17536
(<https://techport.nasa.gov/file/8744>)